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# A Model for Analyzing Strategic Use of Government Financing to Improve Health Care Provision

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Partnerships for Health Reform

PHR

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- *enhanced organization and management of health care systems and institutions to support specific health sector reforms.*

*PHR advances knowledge and methodologies to develop, implement, and monitor health reforms and their impact, and promotes the exchange of information on critical health reform issues.*

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# Abstract

This paper contributes to the debate over public vis-a-vis private provision of health care services in low- and middle-income developing countries with a framework and methods intended to help governments analyze the costs and benefits of different health care financing and provision scenarios, and thus design policy appropriate to their health care goals. It takes into account government interests of health care coverage, equity, and efficiency; provider interests in issues of public and private production of services; and consumer interests of cost, quality, and health benefits. This paper develops an estimable model to help governments decide how best to use scarce resources to achieve priority health goals. Focusing on a single intervention, the model incorporates the separation of financing and provision functions and explicit behavioral assumptions about four key actors: government, public providers, private providers, and consumers. Government can allocate funds between four types of expenditures to increase health outcomes: educating potential users, improving access to public services, improving public service quality, and subsidizing private providers.

# Table of Contents



## List of Tables



## List of Figures

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# Foreword

Part of the mission of the Partnerships in Health Reform Project (PHR) is to advance "knowledge and methodologies to develop, implement, and monitor health reforms and their impact." This goal is addressed not only through PHR's technical assistance work but also through its Applied Research program, designed to complement and support technical assistance activities. The program comprises Major Applied Research studies and Small Applied Research grants.

The Major Applied Research topics that PHR is pursuing are those in which there is substantial interest on the part of policymakers, but only limited hard empirical evidence to guide policymakers and policy implementers. Currently researchers are investigating six main areas:

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- The impact of alternative provider payment systems
- Equity of health sector revenue generation and allocation patterns
- Expanded coverage of priority services through the private sector
- Impact of health sector reform on public sector health worker motivation
- Decentralization: local level priority setting and allocation

Each Major Applied Research Area yields working papers and technical papers. Working papers reflect the first phase of the research process. The papers are varied; they include literature reviews, conceptual papers, single country-case studies, and document reviews. None of the papers is a polished final product; rather, they are intended to further the research process—shedding further light on what seemed to be a promising avenue for research or exploring the literature around a particular issue. While they are written primarily to help guide the research team, they are also likely to be of interest to other researchers, or policymakers interested in particular issues or countries.

Ultimately, the working papers will contribute to more final and thorough pieces of research work, such as multi-country studies and reports presenting methodological developments or policy relevant conclusions. These more polished pieces will be published as technical papers.

All reports will be disseminated by the PHR Resource Center and via the PHR website.

Sara Bennett, Ph.D.
Director, Applied Research Program
Partnerships for Health Reform

# Executive Summary

In many developing countries, governments wanting to provide a set of health care interventions to all persons needing them face a set of policy options for finance and provision. These include using government financial resources to pay for and run a public provision system, and using government funds to pay for private provision. With their goal of increasing health coverage and impact, governments must decide which of these tools to employ incrementally to give the best outcome for a given level of expenditure.

This paper provides a framework for analyzing these choices and a methodology for assisting government decision makers to choose efficient and equitable strategies for reaching their health care goals using public and private provision. The model developed in this paper focuses on the provision of a single health good, such as an annual pediatric check-up or efficacious treatment for a dangerous communicable disease. Public financing and provision are modeled separately, distinguishing the government's decisions regarding financing and public-sector providers' decisions regarding production. On the demand side, utility-maximizing individuals respond to prices and perceived quality of the health good in taking decisions of consuming the health good and, if they do consume, of the choice of the provider. The various policy options available to the government include increasing consumer awareness, since individuals not aware of the potential benefits of the health good will not consume; improving quality of the publicly produced good; reducing consumer expenditure for publicly provided goods; and subsidizing the price of goods produced in the private sector. Analyses of the demand and supply sides yield several policy conclusions that depend on the overall objectives of the government. Significant applications of this model are feasible in developing countries that are relatively data-rich.

# 1. Introduction

There is growing awareness of the important role played by private health care providers in many developing countries (Bennett, 1992). Recent studies have shown that private providers are more numerous than previously thought (Berman et al, 1995, Hanson and Berman, 1997). There is also evidence that they provide better coverage and equity than the government's own providers with intervention for diseases or health actions to which governments assign high priority, particularly those provided on an ambulatory basis, (Berman and Rose, 1996, Berman, 1998). Undesirable characteristics of private provision, such as poor quality of care—including incorrect diagnosis and treatment, overprescribing, and outright harmful practice—are also widely reported. Private providers are usually paid out-of-pocket on a fee-for-service basis, which increases the financial burden on poor populations, resulting in late or inappropriate service use and increased poverty.

These contrary facets of private provision of health care in developing countries have figured prominently in international policy debates, which range from suggesting indiscriminate privatization on the one hand and expectantly waiting for the private sector to wither away on the other. There is a growing consensus that while simply promoting free markets in health care can have very negative social outcomes, private provision under appropriate rules and regulations can play a very positive role in health care.

Interest in the private health sector is further heightened by debates over the proper role of the government in providing health care (Barr, 1993, Besley and Gouveia, 1994, Besley and Coate, 1991, Poterba, 1994). Strong government action is conventionally justified in terms of public and merit goods arguments, as well as equity goals. However, only a few health care interventions fit the classic public goods framework, while most of the services advocated for public action on health and equity grounds are those for which substantial consumer demand exists or would exist if there were greater ability to pay. This is even true in lower-income countries and for many of the interventions proposed as public health priorities, e.g., treatment of communicable diseases such as diarrheas, respiratory infections, tuberculosis, and sexually transmitted diseases. The arguments in support of government action in financing are stronger than those for direct government provision of services, especially where a substantial private provision capacity already exists (Musgrove, 1997).

For example, in many developing countries, there are already many government and private providers of health care in the market, and their capacity to produce the desired services may be individually and jointly greater than or equal to the desired quantity of services. A government wanting to provide a set of interventions to all those needing them faces a choice across a set of policy options for finance and provision. These include using government financial resources to pay for and run a public provision system, and using government funds to pay for private provision, either directly through production subsidies or indirectly through consumption financing. With its goal of increased coverage and health impact, a government must decide which of these tools to employ incrementally to give the best outcome for a given level of expenditure.

Several economists who have looked carefully at such policy questions have argued that theory alone cannot derive a unique optimal solution for such choices. Plausible objective functions for government, public, and private providers, and consumers do not result in clear superiority for either public or private provision on efficiency or even equity grounds (see, for example, Besley and Gouveia, 1994). The authors of this report are persuaded by these arguments, which imply that such

questions should be addressed through empirical analysis of the performance of the different actors and the costs and benefits of different strategies under these conditions. The motivation for this paper is to develop the framework and methods needed to do such analysis for important health interventions in developing countries.

The objective of the present research is to provide a framework for analyzing these choices and a methodology for assisting government decision makers to choose efficient and equitable strategies for reaching their health care goals using public and private provision. The model presented here focuses on the provision of a single health good, such as an annual pediatric check-up or efficacious treatment for a dangerous communicable disease. The model assumes that there are two types of providers, public and private, and that all providers of a type behave similarly. The research separately models public financing and provision, distinguishing the government's decisions regarding financing and public-sector providers' decisions regarding production. It distinguishes between public and private providers by their respective objective functions. Government financing decisions reflect health and equity goals. On the demand side, individuals are assumed to respond to prices, quality of care, and their knowledge of the benefits of the health good.

The rest of the paper is organized as follows. Section 2 describes a situation typical to many but not all developing countries. Section 3 presents the problem statement that this paper seeks to address. The behavioral model is discussed in section 4, followed by numerical applications of the model in section 5. The paper concludes with closing remarks in section 6. The mathematical version of the model is provided in Annex A.

# 2. The Setting: Modelia

Looking across the low- and middle-income countries worldwide, there is great variation in the levels of health care provision as well as the mix of public and private providers and associated institutions (Hanson and Berman, 1998). Consumers' knowledge and ability to pay also varies greatly. In order to carry out the present inquiry, therefore, it is necessary to define some of the general conditions prevalent in the lower middle-income country setting being analyzed. This is the focus of the present section.

The model represents a set of conditions common to many low- and middle-income countries, but not representative of all such settings.[1] Let us call our setting Modelia. Modelia is a lower middle-income country with reasonably well-developed social services and infrastructure for a country at its level of income. Modelia's government has identified a set of health care interventions for which it seeks to assure universal coverage of the population.[2] These interventions have been identified through some process of social choice, which is not explored here. These interventions are not pure public goods; that is, there exists a significant private demand and supply for them.[3] Although Modelia's government budget is limited, there already exists substantial capacity in the public and private sectors to provide these interventions. The government would like to find the best way to use its resources to achieve its goals. These goals include assuring that all who need the priority interventions receive them (coverage), special concerns for disadvantaged groups (equity), and efficiency in the use of resources.

In Modelia, public-sector health services for ambulatory care and public health interventions (the focus in this analysis) are provided by clinics with multiple staff. The government has constructed and staffed an extensive system of clinics in rural and urban areas. These facilities provide care without fees or with very low fees. Despite these conditions, public clinics are underutilized, producing levels of output well below their potential. Low output is related to both demand and supply side factors.

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[1] A key issue in setting out the conditions relevant to this model is the extent to which the environment is "demand constrained" or "supply constrained." It is usually assumed that low- and middle-income countries are predominantly supply constrained. That is, there is insufficient supply available, resulting in high prices, long queues, low quality, etc. This assumption contradicts the observation in many countries that both public and private providers are underutilized. The authors' studies of health care in developing countries suggest that this conclusion may not be valid for all types of health care in many developing countries, including some of the largest ones such as India and China (see, for example, Berman, 1998), but, rather, that for the type of ambulatory care interventions being studied, the majority of the developing world's population does not live in a significantly supply-constrained environment. Of course, one must consider both public and private provision supply and include all those who plausibly could provide the intervention at some reasonable price or cost.

[2] This is compatible with the World Bank's recent emphasis on using cost-effectiveness in health gain as a criterion to set public priorities, although other criteria, such as economic burden on households or the socio-economic conditions of beneficiaries, could also be used (Hammer and Berman, 1995).

[3] There is, of course, private demand and supply for many goods which, due to various market failures or merit arguments, are emphasized for public provision: for example, immunizations, which have significant external benefits. Only the purest public goods, those for which no supply would exist under market conditions, would not be relevant for the current approach.

On the demand side, public clinics are generally perceived to be of minimally acceptable quality, that is, there is some confidence in their technical quality, but they are unpleasant places to visit. Also, their locations, hours, and frequent lack of supplies impose monetary and time costs on users, which may be significant, despite the zero or low fees.

On the supply side, public clinics may have, for historical reasons, suboptimal mixes of inputs, which constrain their productivity. This could include a lack of inputs, such as certain drugs, supplies, or equipment. It could also reflect the low level of government salaries and the inability of government to enforce employment contracts under those conditions, so that health staff simply work fewer hours. Public clinics are not maximizing any discernable objective function. They are producing according to an historical pattern. Simply increasing their budgets according to historical allocations increases their capacity, but may not increase their efficiency. Increased capacity may or may not result in increased output, depending on the demand response. In light of the aforementioned assumption that there is excess capacity in public facilities, increasing their capacity further would not increase demand.

There also exists an extensive network of individual private providers. These providers charge fees for services, which they set according to market conditions. They are profit-maximizers. The technical quality of the services they provide may or may not be at the minimally acceptable level, although patients are not aware of low technical quality by private providers. However, they do provide other amenities to patients, including more convenient locations and hours, nicer physical conditions, and more friendly service.

Consumers seek care in the market, responding to three factors: price, quality, and their perception of their need for the intervention of interest, which this report calls “knowledge.” The total demand in the market is posited to be less than the socially desirable demand, since consumers are constrained by both income (experiencing utilization as an income reduction through the price of using care) and knowledge. They perceive all providers as offering at least minimally adequate technical quality, but they see private providers as possibly being of better technical quality and certainly offering more pleasant and satisfying care. They consider the full cost of seeking care from providers, including the cash price, the possible need to buy additional inputs, and the value of time required for travel and waiting. Some consumers do not understand the value of the services recommended for them, but consumer education can remove this constraint to demand.

# 3. Defining the Problem

As described in the preceding chapter, there already exists in Modelia a quantity of output for the service in question, allocated between public and private providers and distributed throughout the population as a volume of services received or consumed. The market clears, in the sense that some mix of public and private provision meets the existing demand at prevailing prices, quality, and knowledge levels. There still exists excess supply capacity in both public and private provision, which, for some budget and price, could meet additional demand. There also still exists unmet need, related mainly to prices and knowledge, which the government would like to see turned into realized demand.

The current approach is designed to assist the government—to make it a "rational spender." The government, at least in the context of the decisions being studied, is a single actor that seeks to achieve definable social goals. Researchers assume that these goals are determined by some type of representative political process and reflect a social preference function, and thus they do not investigate further the underlying basis of these preferences.

The government in this model has multiple objectives. First, it has a *health* objective. It has chosen to finance a desirable health care intervention based on an appraisal that this intervention is socially desirable and, if used by all who should use it, will result in significant health gain. Its goal of universal coverage is defined to mean that all who are able to benefit from the service (e.g., infants in the case of well-baby care or individuals afflicted with a certain treatable disease), should obtain that service.[4] The government also has an *equity* objective and is especially concerned that people with low income consume the good and do not experience economic hardship because of obtaining the health good. Finally, the government has an *efficiency* objective and seeks to achieve its health and equity objectives at the lowest cost to society.

The approach in this essay is to begin with a description of the initial situation in Modelia and then ask: "Given this situation, if the government can obtain a budget increase for health which it chooses to spend on the intervention being studied, how best should it use the additional money to advance its objectives?"[5] Specifically, it is important to understand under what conditions and in

[4] This paper equates coverage with the health good at an adequate level of technical quality with health impact or health gain. This equality is true if the health benefits of intervention would be equal for all individuals. However, this assumption is unlikely to be valid for any real-world population. However, to introduce variations in health outcomes according to who benefits from the intervention requires addition of information for individuals or groups on their risk of health problems and the potential gains in health. The authors acknowledge that this is an important consideration for government, and hope to introduce this concern in a later version of the model. This paper uses the terms health impact or health gain to represent the benefits of coverage with the health good with adequate technical quality.

[5] The initial question could of course be how should the government choose among all the alternative possible expenditures at the margin to achieve its objectives, i.e., all possible interventions. This wider question is relevant, but somewhat intractable given the number of different health and health care interventions that might be considered. The extensive literature on cost-benefit and cost-effectiveness analysis in health has made little progress in solving this problem. The problem posed here, while more circumscribed, is nonetheless quite realistic. Governments often allocate additional resources to intervention specific programs without analyzing whether such allocative decisions are optimal. The focus here is on allocation decisions *within* such programs, in the expectation that the results will help illuminate the larger question.

relation to which objectives the government would depart from the historical pattern of using additional funds to augment government financing of public provision of services.

To address these questions this paper proposes a generic model of the relevant part of Modelia's health care system. This model includes four actors: the government, public providers, private providers, and consumers. It describes the initial situation, which results from the interaction in the health care market of these four actors. That is, the government has, through historical investments, created a public delivery system that provides the intervention according to known production and cost functions. Private providers also deliver the intervention based on their own production and cost functions. Consumers enter the market and choose either public or private providers, or no provider, based on their utility evaluations. In the initial situation, this market is in short-term equilibrium. The paper then explores how the government, given its objectives, should best use a one-time additional expenditure on the desired intervention.

# 4. Framework of the Generic Model

This section sketches the model, leaving a technical and expanded version to the annex. The model considers the health good to be a discrete, well-defined *unit* such that one person consumes only one unit for each incident of need and there is no gain in utility from consuming more than one unit. A unit can be a single complete intervention or an extended intervention, like *complete* antenatal care or *complete* therapy for a communicable disease such as sexually transmitted disease or tuberculosis. Accordingly, the *eligible* population is defined as all individuals who would benefit from use of the health good. Thus, the eligible population for an annual well-baby visit is all children; similarly, for complete antenatal care the eligible population is all expecting mothers. The market is an administrative area, such as a district, a province, or a country, for which the government makes a budgetary allocation.

## 4.1 Initial Situation

The sketch begins by describing the individual consumer's decision-making process. The population consists of all those who could benefit from the health good. In the model, individuals are differentiated according to two income levels: low income and high income, and according to whether they possess knowledge of the health good, such that those who do not have that knowledge do not consume the health good, although clinically they would benefit from it. Potential consumers can obtain the health good from either public or private providers, and the model treats their choice of provider as a discrete-choice problem. It assumes that the utility that each person receives from consuming the health good is dependent on the quality of the health good, the out-of-pocket expenses associated with procuring the good, the individual's income, and an error term. Quality includes two components: an *observable* component, such as cleanliness, waiting-room decor, politeness of staff, etc., and a *technical* component, such as relevance and appropriateness of treatment, competence of the provider, etc. Consumers are not readily able to differentiate between the two, and what they perceive is some combination that tends to favor the observable but superficial properties of the good relative to the technical characteristics. The term "perceived quality" refers to consumers' perception of quality of care. Increased perceived quality affects the utility function by making the consumption of the health good more pleasant. Out-of-pocket expenses associated with procurement of the health good include payments made out-of-pocket for the health good as well as expenses incurred in the process of procuring the health good. Thus, costs associated with travel, informal payments, etc. are all included in out-of-pocket consumption expenses.

In order to compute total demand for the health good, it is necessary to evaluate the probability that an individual consumes the health good. In order to facilitate this computation, researchers assume a specific distribution form for the error term in the individual's utility function. Multiplying the probability of consumption by the total eligible population gives the expected demand for the health good.

On the supply side, there are many public and private providers producing and delivering the health good. Both provider types produce the health good at least at that level of technical quality that provides positive benefit to the consumer. However, there is a difference in the perceived quality of the health good produced by public and private providers. While the public providers value the technical quality of care they provide, they tend to be indifferent as to how the health good is

perceived by the consumers. On the other hand, private providers attach a positive weight to those attributes of the health good that the consumers are likely to observe and value.

There are other differences between private and public providers in the model. Private providers maximize profits, and thus their objective function is to maximize the difference between revenue and costs. Production decisions by public providers are not a result of optimization of any clearly defined objective function. There is an extensive economic literature proposing and testing models of firm behavior that are alternatives to the well-developed notion of profit maximization. However, at this time there is insufficient information to support any one of these models that attribute different types of motivation to public providers. In the present model, public-sector providers are generally primary health care facilities with multiple staff on salary. They have an inherited capital stock of land, buildings, vehicles, and equipment. They are funded through an annual recurrent budget allocation, which pays salaries and purchases expendable supplies. The supplies and other inputs they receive are based on an historical system, which typically does not assure an optimal mix of inputs. For many other reasons as well (low salaries, low worker morale, etc.), public providers operate below their production possibility frontier. Nominally, they have excess capacity available to produce services.[6]

In this situation, the market equilibrium is characterized by a vector of prices, costs, and out-of-pocket expenses that maximizes profits for the private providers and does not exceed the budgets of the public providers. Of the total population, those who are not aware of the beneficial aspects of the health good have no demand for the good. Of those who have knowledge of the health good, the probability of consumption depends on the relative utility of consumption and non-consumption. Market shares of the two types of providers depend on the perceived quality of their products and the out-of-pocket expenses associated with consumption. As far as the government is concerned, it allocates its entire budget to the public providers only. This is the "initial situation."

## 4.2 Strategic Response Situation

Given these initial conditions, one can then consider the situation in which the government receives a budget increase, but instead of routinely allocating it to the public providers, assesses other ways of allocating the incremental budget so as to meet the objectives of maximizing health coverage, equity, and social efficiency. It is assumed that the initial situation budgetary allocation cannot be changed and that it would be infeasible to close down public facilities even if the production costs in these facilities were very high relative to the private providers.[7] However, the incremental budget may be allocated entirely to any intervention that most effectively optimizes the health coverage, equity, and social efficiency objectives of the government. It also is assumed that the government is

[6] It is paradoxical that public providers should simultaneously be resource constrained and have excess capacity, but in fact that is often the case. One interesting example of this occurred in Indonesia during the 1980s. The government cut the budget allocation to the primary health care system at the same time as it adopted ambitious targets for expanding immunization. Immunization output and coverage increased dramatically at the same time that budgets were reduced. Since the routine utilization of health facilities was well below capacity, it was possible to shift underemployed health workers to immunization work, without affecting other output. Various explanations for such conditions are possible. Workers are poorly paid and typically not well supervised and can adjust their work hours to achieve some reservation wage level from their fixed salaries. Workers may work poorly to keep demand at modest levels. Public facilities have generally received inputs based on population or area norms that have little relation to need or demand.

[7] This assumption could be relaxed to examine the results of any possible allocation of the total budget.

indifferent to where the good is produced, and does not favor either the private or the public sector for any ideological, political, or non-economic reason.

In order to meet one or more of its various objectives, the government can take up one or more of the following "interventions": increase knowledge, subsidize private consumption for a section of consumers, improve perceived quality of public production, and decrease access and other costs that consumers incur at public facilities. Individually and collectively, these interventions meet some aspect of the government's objectives. The first intervention increases the volume of the eligible population, while the other three interventions increase the probability of consumption, and hence volume and health benefits, and potentially change the respective market shares of public and private producers of the health good. This is the "strategic response situation."

This new situation is analyzed using a similar framework to the one used to describe the equilibrium in the initial situation, by incorporating the effect of these interventions in computing the total eligible population as well as the probability of consumption. A subsidy for private consumption will in effect reduce the price the consumers will pay for procuring the health good from private providers. Similarly, subsidizing travel and other costs for public consumption will reduce the out-of-pocket expenses that consumers incur for procuring the good from the public providers. Improving perceived quality of the health good in the public sector will increase the value that consumers attach to public providers. The expected demand function can be recast to take all these effects into account.

Next, in regard to the government budget, each of the four interventions of the government has some direct and associated costs for the government. For ease of exposition, it is assumed that there are no fixed or lump sum costs of producing knowledge and, similarly, that there are no scale economies in financing private-sector price subsidies and public-sector access costs subsidies. Thus, there are direct costs of increasing knowledge, which are simply the product of the unit cost per individual and the number of individuals "educated," and there are direct costs of the subsidies that are the product of unit subsidies and consumption of the health good from that source. The associated costs of increasing knowledge arise from costs of producing the good to meet the additional demand in the public sector and the cost of subsidizing the additional consumption from the private sector. Similarly, the other three interventions also have associated costs, since they will affect the probability of consumption from either of the two providers. Since the respective shares of the public and the private providers is known, it is possible to correctly allocate the associated costs of these interventions to the public providers.

Having described the expected demand function and the budget of the government, the next step is to derive the decision rule for budget allocation so that the various governmental objectives of maximizing coverage, equity, and efficiency can be achieved. In other words, it is to compute numerical values of the interventions that would maximize the objective function of the government subject to the budget constraint. Attaching different weights to the various interventions can emphasize specific objectives. For instance, if the objective is only to improve equity among existing consumers, interventions like educating individuals can be attached a weight of zero. The final step in this theoretical analysis derives some predictions regarding the effect of changes in exogenous factors, such as the budget and costs of the interventions, on the endogenous variables that, in this analysis, are the four interventions.

## 4.3 The Decision Rule

One of the important results of the analysis is the decision rule for governmental allocation of its budget. As stated earlier, the government has three objectives: maximizing health coverage, equity

(which can be represented by a weight given to individual consumption), and efficiency (minimizing cost for a given outcome); and the government has four available interventions: increase knowledge, subsidize private consumption for a section of consumers, improve perceived quality of public production, and decrease access and other costs that consumers incur at public facilities. The problem facing the government is that of deciding how much of the budget to allocate to each intervention so as to maximize cost-effectiveness in equity-weighted health outcomes.

The decision rule suggested by the theoretical analysis is as follows: "In order to maximize its objectives, the government must allocate its budget so as to equalize, for every intervention, the ratio of the marginal increase in equity-weighted demand resulting from the particular intervention to the costs associated with that intervention." Specifically, in the equilibrium, these ratios should have the common value equal to the marginal utility of the budget money when the government objective is maximized.

This decision rule implies that the government should keep spending on all available interventions until the marginal gain in the overall objective of the government attributable to a particular intervention (i.e., the gain in weighted demand from the last dollar spent on that intervention) is the same across all interventions. It is easy to see that this should be the case, for if it were not and the marginal gain from, for instance, investing in education was higher than the marginal gain from subsidizing private providers, greater benefits could be achieved from spending more on education compared to subsidy. However, if the marginal gains were the same across all interventions, no further increases in overall gain would be possible from any reallocation.

## 4.4 Comparative Statics

The model also makes it possible to predict how the equilibrium values of the endogenous variables, in this case the four interventions, will change when there is a change in any of the exogenous variables or parameters, chiefly the budget and costs of the interventions. Referred to as comparative-static analysis, the ability to predict these changes is critical in resource allocation decisions of this type, insofar as the policymakers can infer, ex-ante, the impact of factors on which they have may have little control.

An illustration is to examine the effect of a change in the budget on the equilibrium values of expenditures on improving consumer awareness and on subsidizing consumers purchasing the good from private providers. This analysis predicts that an increase in the government budget would lead to greater outlays on improving awareness and knowledge among potential consumers. Similarly, so long as an increase in subsidy for private production increases the probability of consumption, an increase in the government budget would also lead to an increase in subsidy for private production, everything else remaining constant.

Next is to examine the impact of a change in the costs of the intervention on the optimal purchase of that intervention. As is usual in this kind of analysis (refer, for instance, to the Slutsky decomposition), it is useful to decompose the effect of a change in the cost of an intervention into two parts: the effective reduction in the available budget, also called the income effect, and the effective decrease in the costs of other interventions, also known as the substitution effect. The theoretical analysis presented here shows that the income effect is unambiguously negative. The substitution effect will also be negative when an increase in the use of one intervention does not reduce health coverage due to other interventions already in use.

The final element to examine is the impact of a change in the costs of one intervention on the optimal purchase of the other intervention, again decomposing the comparative-static derivative into two components, an income effect and a substitution effect. Analysis shows that the income effect is negative while the substitution effect is positive, so that the combined effect will depend on the relative strengths of the two and is, in theory, indeterminate. This means that the two interventions, say those of increasing education and of subsidizing private consumption, will be "substitutes" if the negative income effect is weaker than the positive substitution effect and an increase in the cost of one intervention leads to an increase in the purchase of the other. On the other hand, the two interventions will be "complements" if the income effect is stronger, and the increase in the costs of one intervention leads to a fall in the purchase in the other. The determination of the final sign is an empirical matter.

## 4.5 Comparison of the Initial Situation and the Strategic Response Situation

Recall that the equilibrium in the initial situation is characterized by some consumers and some non-consumers. The former are split in some manner between public and private providers, and the latter in the non-consumption situation either because of lack of knowledge or lack of purchasing power or both. Public-sector providers receive a budget from the government, which is used to finance production of the health good at some acceptable level of clinical quality. In the strategic response situation, the government receives a budget increase that can be used to finance some or all of the four interventions: increasing consumer awareness, improving perceived quality in the public sector, subsidizing access costs to consumers of the publicly provided good, and subsidizing costs to consumers of the privately produced good. Accordingly, public providers receive additional funds that are especially earmarked for various uses: public production, improvement in perceived quality, and reduction in access costs to consumers. Following government spending on increasing consumer awareness, more people become aware of the benefits of consuming the health good, which increases the demand for the health good. Similarly, among those who have knowledge of the health good, demand for the health good also increases following improvements in the perceived quality of public production, reduction in access costs for consumers of the health good produced in the public sector, and subsidy to consumers procuring from the private sector.

The differences in outcomes between the resource allocation methods of the initial situation and the strategic response situation are summarized in Table 1.[8]

[8] This paper has not applied the "strategic response" to the total government expenditure, nor has it shown estimates of use of the budget increment without the strategic response. For the latter, the entire incremental budget would be given to public providers as general budgetary support. Given the assumptions, there would be no change in outcome, simply an increase in excess capacity in public provision. For the former, it assumes that government's initial supply and expenditure pattern is fixed and hard to change. The model could, with some modifications, analyze a "zero-base" budgeting problem as well.

**Table 1: Impact of Different Resource Allocation Strategies**

| Impact on: | The Initial Situation Strategy | The Strategic Response Situation |
|---|---|---|
| Budget Allocation | Budget allocated to public providers on an historical basis | Initial budget allocated to public providers as before. Incremental budget allocated for increasing consumer awareness, subsidizing procurement from private providers, improving perceived quality of public production, and reducing access costs of public sector consumers, following an optimization decision rule. |
| Public Providers | Receive all government budget for the health good; no emphasis on improving quality or reducing other consumer costs | Likely to receive part of the incremental budget for use in improving quality and reducing other costs to consumers. |
| Private Providers | Respond to profit maximization motives and to quality and quantity in government | Respond to profit maximization motives and to quality and quantity in government. Government subsidy for consumers of private sector likely to attract many new consumers. |
| Consumers | Only those aware of the product and obtaining higher utility from consumption having some demand for the health good; distributed between the public and private sectors according to individual evaluation of quality and costs | More individuals aware of the health good; increase in overall demand and coverage; improvements in public-sector quality and reductions in public-sector access costs likely to attract many new consumers to the public sector. Subsidies attract consumers to the private sector. |
| Health coverage | Lower | Higher |
| Equity | Addressed through low fees in the public sector | Addressed through (i) educating people about the potential benefits of the health intervention; and (ii) subsidies to private sector provision. |

# 5. A Numerical Example

This section presents results of a numerical example based on an operational version of the theoretical model.[9] In particular, it assumes that the utility function is additive in (log of) income net of expenditure associated with procurement of the health good, and quality. In other words, the utility of an individual *k* belonging to income group *i* (*i* = 1, 2) choosing provider *j* (*j* = public, private) is expressed as follows:

$$U_{kij} = \log (Y_{ki} - C_{kij}) + q_j + \varepsilon_{kj} \qquad (1)$$

where *i* = income groups 1, 2; *j* = *v* (private providers), *g* (public providers); $C_{kij}$ denotes the out-of-pocket expenditure on the health good, $q_j$ denotes the quality of the good, and $\varepsilon_{kj}$ is a random variable which captures the noise in the interpretation of quality by individual *k*. $C_j$ has two components: the price that the consumer pays for the good, $P_{kij}$, and other expenditure, such as transportation cost, waiting cost, etc., collectively represented by $T_{kij}$.

An individual will consume the health good if the utility received from consumption is greater than (or equal to) the utility from non-consumption. The probability of consumption is computed on the assumption that the error term in the individual's utility function follows the exponential distribution. Total demand for the health good is computed by multiplying the probability of consumption by the eligible population, and is expressed as follows:

$$D = \sum_{i=1}^{2} \left[ N_i \{1 - (1 - \lambda \exp(-\lambda A_{2i}))(1 - \lambda \exp(-\lambda A_{3i}))\} \right] \qquad (2)$$

where $N_i$ = eligible population in income group *i*

$A_{2i} = \log \{Y_i / (Y_i - C_v)\} - q_v$

$A_{3i} = \log \{Y_i / (Y_i - C_g)\} - q_g$

The market shares of public and private providers can be similarly computed (see Annex A for details):

$$D_g = \sum_{i=1}^{2} N_i \{\exp(-\lambda A_{3i}) - \frac{1}{2}\exp(-\lambda(A_{2i} + A_{3i}))\} \qquad (3)$$

$$D_v = \sum_{i=1}^{2} N_i \{\exp(-\lambda A_{2i}) - \frac{1}{2}\exp(-\lambda(A_{2i} + A_{3i}))\} \qquad (4)$$

[9] For ease of exposition, the example does not include any equity weights.

Recall that the government can take up one or more of the following "interventions": increase knowledge, subsidize private consumption for a section of consumers, improve perceived quality of public production, and decrease access and other costs that consumers incur at public facilities. These interventions affect consumption of the health good in different ways: increasing knowledge increases the share of the eligible population, subsidy for private consumption reduces the price of the health good produced by private providers, while subsidizing travel and other costs for public consumption reduces the out-of-pocket expenses that consumers incur for procuring the good from the public providers. Improving perceived quality of the health good in the public sector increases the value that consumers attach to public providers. Taking all these effects into account, the expected demand function and the respective market shares can be rewritten as follows:

$$D^{SR} = \sum_{i=1}^{2} [(\alpha N_{iu} + N_i)\{1 - (1 - \lambda \exp(-\lambda A_{2i}))((1 - \lambda \exp(-\lambda A_{3i}))\} \ ] \quad (5)$$

$$D_g^{SR} = \sum_{i=1}^{2} (\alpha N_{iu} + N_i)\{\exp(-\lambda A_{3i}) - \frac{1}{2}\exp(-\lambda(A_{2i} + A_{3i}))\} \quad (6)$$

$$D_v^{SR} = \sum_{i=1}^{2} (\alpha N_{iu} + N_i)\{\exp(-\lambda A_{2i}) - \frac{1}{2}\exp(-\lambda(A_{2i} + A_{3i}))\} \quad (7)$$

where:

| | | |
|---|---|---|
| $N_{iu}$ | = | population in income group *i* that does not have knowledge of the health good |
| . | = | fraction of the population covered by the government intervention of increasing knowledge |
| $A_{2i}$ | = | $\log \{Y_i / (Y_i - [(1-.)P_v + T_v]\} - q_v$ |
| $A_{3i}$ | = | $\log \{Y_i / (Y_i - [P_g + (1-.)T_g\} - (1+.)q_g$ |
| . | = | fraction of price charged by private providers that is subsidized |
| $P_j$ | = | price charged by provider *j* |
| $T_j$ | = | travel and other costs incurred by consumers in procuring the good from provider *j* |
| . | = | fraction of consumers' out-of-pocket expenditure on travel and other costs that is subsidized |
| . | = | fraction improvement in perceived quality of the health good produced by public providers |

Next is to describe the budget of the government and note that each of the four interventions of the government has some direct and associated costs for the government.

In particular the incremental budget constraint of the government is written as follows:

$$dB = \sum_{i=1}^{2} \{\rho\alpha N_{iu} + \sigma P_v D_v^{SR} + (\kappa + \eta(1+\beta)q_g + \tau(1+\delta)T_g)D_g^{SR}\} \quad (8)$$

Where dB = incremental budget
. = cost of educating one individual
. = cost of production of one unit of the health good in the public sector
. = cost of increasing perceived quality of public production by one unit
. = cost of reducing consumer access costs by one unit

In order to maximize the objective function, the model follows standard techniques and sets up the Lagrangian equation, which gives one equation with four unknowns, the unknowns being the respective values of the four interventions.

It now is possible to compute those values of ., ., . and . that would maximize the objective function of the government subject to the budget constraint, by maximizing (5) subject to (8) and computing the relevant first-order conditions that yield the necessary conditions for a maximum. The model uses stylized facts about Modelia to substitute numerical values for all the known variables in the system and obtain a solution that maximizes the objective function subject to the budget constraint.

Specifically, assumptions are that the total population of Modelia is 1,150,000, divided into two income categories. There are 1,000,000 people in the low-income category, with an average annual income of M$100, and 150,000 in the high-income category, with an average annual income of M$300 (where M$ refers to Modelia dollars). Of these, 600,000 persons in the low-income category and 50,000 in the high-income category are not aware of the health good. Of the rest, those who consume the health good do so from either the public or the private sector. The price of the health good supplied by public providers is only M$1 compared to M$20 charged by private providers. Travel and other costs, however, are higher for public-sector consumers, who spend M$10 compared to the M$5 spent by private-sector consumers. Consumers perceive quality of private providers superior to public providers by a ratio of 5:1.

Substituting for income, cost and quality in equations 2, 3, and 4, the total demand for the health good and its distribution between public and private providers can be calculated: Of the high-income group, 100,000 people demand the health good, and of the low-income group, 400,000 people demand the good. Of the total demand of 500,000 units, public providers supply 265,000 units and private providers supply 235,000 units. In other words, of the 1,150,000 people in Modelia, only 500,000 demand and consume the health good, leaving 650,000 people who are not covered by the health good.

The government now receives an additional budget allocation of M$1,000,000. It can use these additional funds in one or more of the following ways: finance additional production in the public sector; increase consumer education and awareness; subsidize private-sector consumption; subsidize transportation and other costs incurred by consumers at public facilities; and improve quality of the health good produced in the public sector. The average cost of producing the health good in the public sector is known to be M$3. Similarly, education and awareness campaigns are known to cost M$1.5 per individual covered, improvements in perceived quality to cost M$1 per unit level increase. It is

assumed that there are no capacity limitations in the public sector, and public providers can supply any quantity of the health good. Private providers, however, face some capacity constraints, and can provide a maximum of 500,000 units of the health good.

If the government were to spend the entire additional budget on consumer education and awareness campaigns, all the remaining 650,000 people hitherto unaware of the benefits of the health good would be covered. However, the government would have no funds left to finance the additional demand of the publicly provided health good following this increase in eligible population. Alternatively, the government could use the entire increase in the budget to subsidize private consumption. This would reduce the price of the good for 50,000 existing consumers, but would not increase health coverage at all. Similarly, investments in subsidizing transport costs at public facilities or improving quality of the publicly produced good would not increase health coverage.

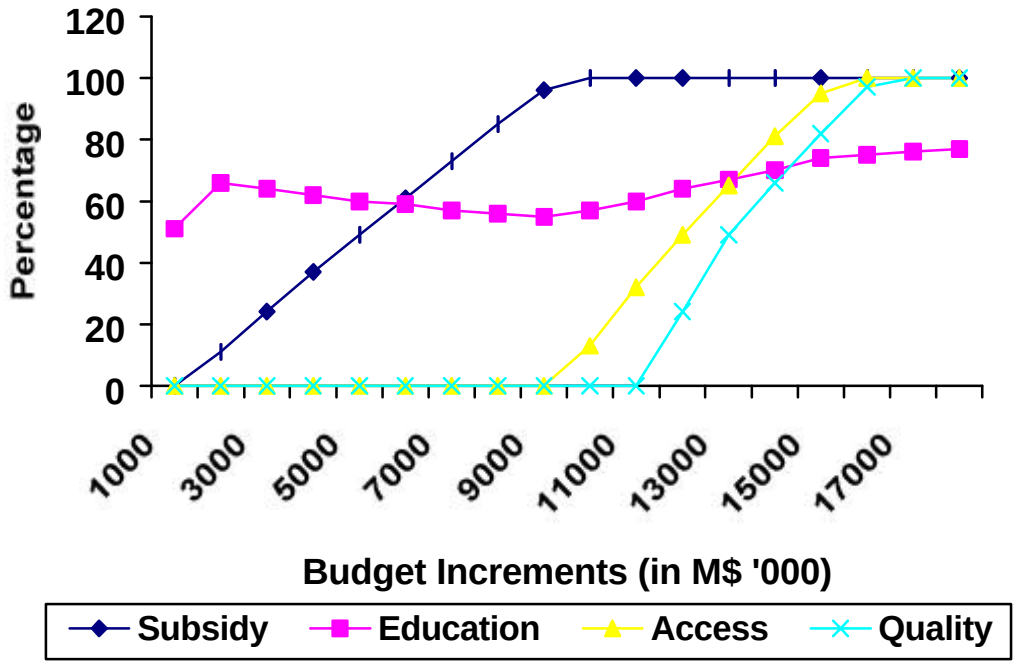
The model suggests that in this situation the government should use the additional funds on education and awareness programs so as to cover 331,500 people. It predicts that this will lead to an increase in demand for the publicly provided health good by 167,583 units, the production of which the government can finance with the funds left over in the incremental budget after spending on education.

Consider now the situation in which the government receives M$2,000,000 instead of half this amount as in the previous case. As before, the government faces many choices across many options. Spending the entire amount on education and awareness campaigns would, as before, cover the remaining 650,000 people, but would not leave enough funds with the government to finance the production required to meet the additional demand for the publicly provided good. The model suggests that the government should use the additional funds on education and awareness campaigns so as to cover 429,000 people. This would lead to an increase in demand for the publicly provided health good by 248,820 units. After providing enough funds for production of this quantity in the public sector, there is enough left over in the government budget to subsidize the private sector health good by M$2.8 per unit.

The model suggests spending increasingly on subsidizing consumers for purchase of the health good from the private sector, while holding spending on education and awareness campaigns almost constant at the coverage level of around 425,000 people. However, once the maximum that the consumers can purchase from the private sector is fully subsidized, the model suggests that larger gains would be obtained by increasing spending first on subsidizing transport and other costs for consumers in the public sector and later on improving public-sector quality.

Optimal allocations of incremental budgets are presented graphically in figure 1. The vertical axis measures percentage increments in the four intervention variables, while the horizontal axis depicts budgetary increases. Thus, when the budget increment is only M$1,000,000, figure (1) shows 51 percent of the 650,000 people hitherto unaware of the benefits of the health good should be covered by education and awareness campaigns. Similarly, when the budget increment is of the order of M$6,000,000, the model suggests education coverage of approximately 60 percent of 650,000 (i.e., 422,500), and subsidy of the private sector good of the order of 61 percent (i.e., M$12.20).

**Figure 1. Level of Different Interventions Purchased with Budget Increments (%)**




Note: 1. "Level of subsidy" measured on the y-axis refers to the percentage of the price of the health good procured from private providers that is subsidized by the budget increment;
2. "Level of Education" measured on the y-axis refers to the percentage of the population hitherto unaware of the benefits of the health good that is covered by the budget increment;
3. "Level of access" measured on the y-axis refers to the percentage of transportation and access costs that consumers incur in procuring the good from the public providers that is subsidized by the budget increment;
4. "Level of quality" measured on the y-axis refers to the percentage improvement in the quality of the health good produced in the public sector.

Suppose, however, that the cost structure is different than the one assumed so far. Specifically, suppose that the education and awareness campaigns cost M$10 per person, which is much higher than the M$1.5 assumed in the previous instance. Also, suppose that the travel and other costs to those who consume from the private sector is M$20, also much higher than the M$5 assumed in the earlier instance. All other costs are the same as assumed before.

Since procurement of the private sector good now costs the consumer M$40, compared to the M$11 that the public-sector consumers spend, it is reasonable to expect that subsidizing private-sector consumption will produce larger gains. Furthermore, the high cost of educating a prospective consumer would also make alternative interventions more appealing. The model predicts quite along these lines.

The simulation results of M$1,000,000 increments in the budget appear in Figure 2. As before, the vertical axis measures the percentage increments in the four intervention variables, while the horizontal axis depicts budgetary increases. The model suggests that largest gains would be obtained by subsidizing the expensive private-sector good, and only when the entire consumption of the privately produced good is subsidized should the incremental funds be used for education and awareness campaigns. In the present case, this situation would occur at a budget of M$5,000,000, at

which point the entire consumption of the private-sector production is subsidized. Subsequent budgetary increments are invested in increasing education and awareness.

The preceding examples have considered those cases in which, given the incremental budget, the problem facing the government is that of designing the optimal mix of the various interventions so as to maximize coverage. They presented two illustrations of the applicability of the model under various capacity and costs assumptions and showed how the mix of interventions differs depending on the relative costs of the interventions and the production constraints in the public and private sectors. In planning for full coverage, however, governments may often face a different question: Given the constraints imposed by income, education, costs, and production capacity, what is the minimum level of funding that the government would have to provide to ensure full coverage?

This point is illustrated by considering the cost structure situation of the first example in this section. Thus, education and awareness campaigns cost M$1.5 per person, and travel and other costs to those who consume from public providers are M$5 per visit. Recall that of the total population of Modelia of 1,150,000, 650,000 are not aware of the benefits of the health good. Since education is a necessary condition for consumption of the health good in this model, the government would, at the minimum, have to arrange for funds sufficient to meet the costs of education and awareness campaigns. If there are no income and production constraints, this allocation would be sufficient to achieve full coverage. Thus, the model predicts, rather trivially, that it would cost the government M$975,000 only to achieve full coverage.

The requirement of funds changes very significantly in the presence of capacity constraints and income considerations. Consider the situation in which the private sector can produce only 500,000 units of the good. Full coverage in this case becomes very difficult, because there will always be some people who, despite being aware of the health good, will not procure the good from either provider, either because of high costs of procurement or low valuation of the health good due to low perceived quality. Given the wide gap between perceived quality of private- and public-sector good in the example, the government will not be able to achieve full coverage since there will always be some people who will derive lower utility from consuming a health good to which they attach lower quality relative to not consuming.

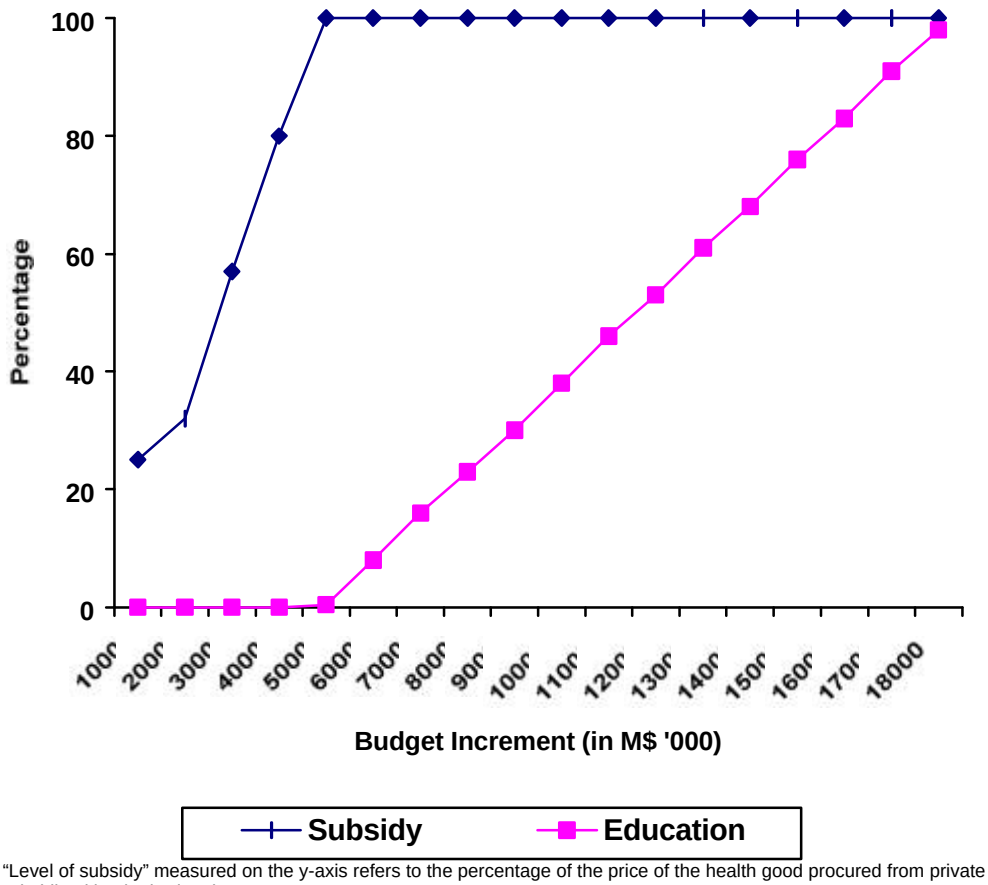
Suppose, however, that the private-sector production capacity is 600,000 units, and there is no capacity constraint in the public sector. In this case, the model predicts that it would require approximately M$17,500,000 to achieve full coverage. This equilibrium will be characterized by coverage of the entire population under the education and awareness programs. The price of the health good produced by private providers would be fully subsidized, and there would be no excess supply in the private sector. Of the M$10 spent by consumers of publicly provided goods, M$8.41 would be subsidized by the government.

Finally, suppose that there is no capacity constraint in private-sector production, but that the public sector cannot produce more than 500,000 units. In this case, full coverage would require approximately M$18,280,000. The equilibrium would be characterized by full coverage under the education and awareness programs, full subsidy of private consumption, and M$7.60 subsidy of access and transportation costs for consumers in the public sector.

All these calculations are based on the stylized facts assumed for Modelia, and the results are sensitive to the monetary values assigned to the various costs. In particular, the model is sensitive to the cost of production in the public sector, and travel and other costs for public- and private- sector consumers. And finally, the model is also sensitive to the relative valuation of quality of the health good produced in the two sectors. To this extent, therefore, options such as subsidizing private-sector

consumption and encouraging public production can be compared only after taking into consideration the relevant income, costs, and quality data.

**Figure 2. Level of Different Interventions Purchased with Budget Increments (M$)**




Note: 1. "Level of subsidy" measured on the y-axis refers to the percentage of the price of the health good procured from private providers that is subsidized by the budget increment;
2. "Level of Education" measured on the y-axis refers to the percentage of the population hitherto unaware of the benefits of the health good that is covered by the budget increment;

# 6. Conclusion

The preceding sections have considered a situation typical of many developing countries and suggested an alternative way of thinking about budget allocation. The analysis has been motivated by a set of stylized facts that the authors believe represents many real-world situations. It starts with the premise that the state seeks to assure universal coverage with a health care service of proven benefit. A significant supply of public- and private-sector providers exists, capable of providing the service such that it will have a benefit (adequate technical quality), but varying in terms of their production costs, prices, and other costs to users, and the amenities they provide that affect consumers' perceptions of quality of service. Consumers choose to procure the service based on their knowledge and income and, if they seek the service, they choose either public or private providers in response to differences in prices and perceived quality.

Historically, the government has only acted to produce services through budget financing of the public-sector providers. The government now explores the use of a larger set of instruments to achieve its objectives, which include health, equity, and social welfare goals. How best can the government use its money to finance private provision, or use other actions to advance its objectives?

Through explicit assumptions about the behavior of the four actors—government, public and private providers, and consumers—the model has derived the basic behavioral relationships that can provide answers to this question. The model can be adapted to address a variety of possible scenarios and many relevant policy questions. The numerical examples that have been generated by the model and described in this report emphasize and illustrate the practical usefulness of the theoretical framework.

In most developing countries, governments have focused almost all their health resources on expanding public provision scope and activity. This approach has been justified by the expected low cost of public provision versus alternatives. While low cost services are available in many countries, consumers, even poor consumers, often choose to use non-government providers at higher cost or to forego services they need. The model presented here is based on the notion that the high or even full coverage that the government seeks to provide requires action on both the demand and supply sides. It provides a systematic and flexible framework for assessing strategic use of government to achieve health goals.

Significant applications of the model are feasible in developing countries that are relatively data-rich. The variables on which data is required include demand, supply, and market elements. Demand-side data include information on the socio-demographic and economic profile of users of the specific health services, utilization rates, prices and expenditures, mode of transportation, waiting time, etc. Supply-side data include information on producers and financiers of health services, and cover such aspects like quality, access, costs, range of services, etc. Market elements include data on such aspects as health producing and financing institutions and government regulation.

This model can be estimated to focus on designing the optimal strategy for use of government funds in terms of supporting or expanding existing government provision, or financing existing or new private provision for a specific type of intervention, given existing conditions of supply. It can analyze the desirable allocation of resources given a mix of objectives for public action and different levels of incremental budget. Alternatively, it can analyze the optimal mix of action to achieve stated

goals at least cost. As this paper has demonstrated, simulations can be done to estimate the sensitivity of public expenditure decisions on new investment, strengthening of existing public services, or financing of private provision to the value range of key variables and parameters in the model. The results highlight the circumstances from both the supply and demand sides that make the different policy choices more desirable, as well as the possible direction and magnitude of effects in terms of cost, coverage, equity, and health outcomes.

A final caveat is to note that any model of individual and institutional behavior is only as good as the assumptions that go into giving the model more structure and making it operational. Thus, the authors have made some assumptions of the utility function of the individual, and the distribution of the error term. Before wide generalizations are generated from this model, it will be useful to test the robustness of the results under varying behavioral assumptions. This is an exercise for future research.

# Annex A. Mathematical Model

For this model, we define:

(i) the health good to be a discrete, well-defined unit such that one person consumes only one unit in one year and there is no gain in utility from consuming more than one unit;

(ii) the eligible population to consist of all individuals who would benefit from use of the health good;

(iii) the market to be an administrative area, such as a district, a province, or a country, for which the government makes a budgetary allocation.

There are four players in the model: consumers, public providers, private providers and the government. We start by describing the decision-making processes of these players in the situation in which the government allocates its entire budget to the public providers, who produce at levels determined by their average costs. Individuals take a decision on consumption and source of the health good as a result of utility maximization. Private providers base their production decision on profit maximization. This is called the "initial situation." Using a similar framework, we analyze the situation in which the government, on receiving a budget increment, decides to allocate its budget strategically across many interventions, which are individually and collectively designed to meet one or more of the government's objectives of maximizing coverage, equity, and efficiency. This is the "strategic response situation."

## Consumption Decisions

The model differentiates individuals according to two income levels: low income and high income, and according to whether they possess knowledge of the health good, such that those who do not have that knowledge do not consume the health good, although clinically they would benefit from it. Potential consumers can obtain the health good from either public or private providers, and we model their choice of provider as a discrete-choice problem. We assume that the utility that each person receives from consuming the health good is dependent on the quality of the health good, the out-of-pocket expenses associated with procuring the good, the individual's income, and an error term. Out-of-pocket expenses associated with procurement of the health good include payments made out-of-pocket for the health good as well as expenses incurred in the process of procuring the health good. Thus, costs associated with travel, informal payments, etc. are all included in out-of-pocket consumption expenses.

In particular, the utility of an individual $k$ belonging to income group $i$ ($i$ = 1, 2) choosing provider $j$ ($j$ = public, private) is expressed as follows:

$$U_{kij} = \log (Y_{ki} - C_{kij}) + q_j + e_{kj} \qquad (1)$$

where $I$ = 1 (low-income group), 2( high-income group);
$j$ = $v$ (private providers), $g$ (public providers);
$C_{kij}$ = out-of-pocket expenditure on the health good,
$q_j$ = perceived quality of the health good; and
$e_{kj}$ = a random variable that is independently and identically distributed across patients and providers and has an exponential distribution with parameter ..

$C_{kij}$ has two components: the price that the consumer pays for the good, $P_{kij}$, and other expenditure, such as informal payments, transportation cost, etc., collectively represented by $T_{kij}$.

Thus, the utility of an individual who purchases the health good from the private provider can be expressed as:

$$U_{kiv} = \log (Y_{ki} - C_{kiv}) + q_v + \varepsilon_{kv} \quad (2)$$

Similarly, the utility of an individual who purchases the health good from the public provider is:

$$U_{kig} = \log (Y_{ki} - C_{kig}) + q_g + \varepsilon_{kg} \quad (3)$$

Individual $k$ will consume the service if either is greater than utility from not consuming. In other words, if the utility from non-consumption is:

$$U_{ki(\sim j)} = \log Y_{ki} \quad (4)$$

the individual will consume the health good if either (5) or (6) or both of the following hold:

$$\log (Y_{ki} - C_{kiv}) + q_v + \varepsilon_{kv} > \log (Y_{ki}) \quad (5)$$

$$\log (Y_{ki} - C_{kig}) + q_g + \varepsilon_{kg} > \log (Y_{ki}) \quad (6)$$

(5) and (6) are respectively equivalent to

$$\varepsilon_{kv} > \log \left[ \frac{Y_{ki}}{(Y_k - C_{kiv})} \right] - q_v = A_{2k} \quad (7)$$

$$\varepsilon_{kg} > \log \left[ \frac{Y_{ki}}{(Y_{ki} - C_{kig})} \right] - q_g = A_{3k} \quad (8)$$

The probability that an individual will consume is:

$$P(C) = \left\{1 - P(e_{kv} < A_{2k})P(e_{kg} < A_{3k})\right\} \tag{9}$$

Since the density of the error term is:

$$F(e) = le^{-lx} \qquad x \geq 0 \tag{10}$$

The probability that an individual will consume the health good can be expressed as:

$$\begin{aligned} P(C) &= \left\{1 - (1 - le^{-lA_{3k}})(1 - le^{-lA_{2k}})\right\} && if \quad A_{2k} > 0; A_{3k} > 0 \\ &= le^{-lA_{3k}} && if \quad A_{2k} < 0; A_{3k} > 0 \\ &= le^{-lA_{2k}} && if \quad A_{2k} > 0; A_{3k} < 0 \\ &= l && otherwise \end{aligned} \tag{11}$$

For some low values of $C_{kij}$ and high values of $q_j$, both $A_{2k}$ and $A_{3k}$ will be less than zero, and the probability of consumption will simply be .. The intuition behind this becomes apparent if .=1, implying that at some low levels of expenditure on the health good and for some high levels of perceived quality of that health good, there is 100% chance that the individual will consume the good. In what follows, we restrict ourselves to the more interesting (and likely) case in which both $A_{2k}$ and $A_{3k}$ are positive.

Expected demand for the health good can be expressed as:

$$ED = \sum_{i=1}^{2} N_i \left\{1 - (1 - le^{-lA_{3k}})(1 - le^{-lA_{2k}})\right\} \tag{12}$$

Public providers will be preferred over private providers if:

$$\log (Y_{ki} - C_{kig}) + q_g + e_{kg} > \log (Y_{ki} - C_{kiv}) + q_v + e_{kv} \tag{13}$$

Collecting the error terms on one side and manipulating,

$$\varepsilon_{kh} - \varepsilon_{kv} > \log \left[ \frac{Y_{ki} - C_{kiv}}{(Y_{ki} - C_{kig})} \right] + q_v - q_g \qquad = A_{3k} - A_{2k} \tag{14}$$

We are now in a position to compute the market shares of the private and public providers. The probability that the individual will purchase from the private providers is:

$$
\begin{aligned}
P_{ki}(v) &= P\left\{\varepsilon_{kv} > A_{2k} \quad \& \quad \varepsilon_{kg} - \varepsilon_{kv} < (A_{3k} - A_{2k})\right\} \\
&= \int_{A_{2k}}^{\infty} \lambda e^{-\lambda v} \int_{0}^{v+(A_{3k}-A_{2k})} \lambda e^{-\lambda g} dg dv \qquad if \quad A_{2k} + (A_{3k} - A_{2k}) > 0 \\
&= e^{-\lambda A_{2k}} - \frac{1}{2} e^{-\lambda (A_{3k} + A_{2k})} \\
&= \int_{-A_{1k}}^{\infty} \lambda e^{-\lambda v} \int_{0}^{v+(A_{3k}-A_{2k})} \lambda e^{-\lambda g} dg dv \qquad if \quad A_{2k} + (A_{3k} - A_{2k}) < 0 \\
&= \frac{1}{2} e^{\lambda (A_{3k} - A_{2k})}
\end{aligned}
\tag{15}
$$

Similarly, the probability that the individual will consume from public providers is:

$$
\begin{aligned}
P_{ki}(g) &= P\left\{\varepsilon_{g} > A_{3k} \quad \& \quad \varepsilon_{kg} - \varepsilon_{kv} > (A_{3k} - A_{2k})\right\} \\
&= e^{-\lambda A_{3k}} - \frac{1}{2} e^{-\lambda (A_{3k} + A_{2k})} \qquad if \quad A_{3k} - (A_{3k} - A_{2k}) > 0 \\
&= \frac{1}{2} e^{-l (A_{3k} - A_{2k})} \qquad if \quad A_{3k} - (A_{3k} - A_{2k}) < 0
\end{aligned}
\tag{16}
$$

The market shares of public and private providers are simply the product of the respective probabilities and the number of people in the eligible population.

## Production Decisions

At any time, there are many private and public providers present in the market. We assume that all public providers are alike and can be thought of as a homogenous group. Similarly, all private providers are also alike and can also be thought of as a homogenous group. However, there are many differences between public and private providers. First, private providers are profit maximizers and take decisions accordingly. On the other hand, decisions of public providers are not the result of any optimization process; rather, they are responses to budgetary allocations from the government. Second, private providers charge a fee for their services, and the fee is determined as a result of the profit maximization exercise. On the other hand, fees in the public sector are set by the government, and are either zero or very close to zero. Finally, private providers care how their quality is perceived by the prospective consumers, while the public providers are indifferent to consumer perception.

Both, however, produce at some level of technical quality so that the consumer derives positive utility from the health good.

Public providers produce at a marginal cost, which is constant for a level of quality. Thus,

$$MC_g = \kappa + \eta q_g \quad (17)$$

There are no fixed costs of production and no investment decisions to be made. Given the budgetary allocation from the government, B, public providers supply $B/MC_g$ units of the good.

We do not explicitly model the production decision process of the private providers, except to note that the production technology is such that they produce at a constant cost of . per unit. Given their market shares and costs, they set prices so as to maximize their profits.

We assume that there is excess capacity in both public and private sectors, and no new capital investment is required to increase production in either sector. We further assume that there is no interaction between public and private providers, in the sense that production decisions in neither sector are affected by production decisions in the other sector.

## The Initial Situation Equilibrium

In the initial situation, the government allocates its entire budget to the public providers.

In this situation, the market equilibrium is characterized by production costs, output levels, prices, and out-of-pocket expenses that maximize profits for the private providers and does not exceed the budgets of the public providers. Of the total population, those who are not aware of the beneficial aspects of the health good have no demand for the good. Of those who have knowledge of the health good, the probability of consumption depends on the relative utility of consumption and non-consumption. Market shares of the two types of providers depend on the perceived quality of their products and the out-of-pocket expenses associated with consumption.

## Strategic Response Situation

We now consider the situation in which the government receives a budget increase, but instead of routinely allocating it to the public providers, considers various other ways of allocating the incremental budget so as to meet the objectives of maximizing health coverage, equity, and social efficiency. We assume that the existing budgetary allocation cannot be changed and that it would be infeasible to close down public facilities even if the production costs in these facilities were very high relative to the private providers. However, the incremental budget may be allocated entirely to any intervention that most effectively optimizes the health coverage, equity and social efficiency objectives of the government. We further assume that the government is indifferent where the good is produced, and does not favor either the private or the public sector for any ideological, political, or non-economic reason.

In order to meet one or more of its various objectives, the government can take up one or more of the following “interventions”: increase knowledge, subsidize private consumption for a section of consumers, improve perceived quality of public production, and decrease access and other costs that

consumers incur at public facilities. Individually and collectively, these interventions meet some aspect of government's objectives. The first of these interventions increases the volume of the eligible population, while the other three interventions increase the probability of consumption and potentially change the respective market shares of public and private producers of the health good.

We use a similar framework as we did to describe the equilibrium in the initial situation, and incorporate the effect of these interventions in computing the total eligible population as well as the probability of consumption. A subsidy for private consumption will in effect reduce the price the consumers will pay for procuring the health good from private providers. Thus, if the subsidy is σ%, consumers pay $P_v(1-\sigma)$ for private providers' services. Similarly, subsidizing travel and other costs for public consumption will reduce the out-of-pocket expenses that consumers incur for procuring the good from the public providers. Thus, if the subsidy for these expenses is δ%, public provider consumers will spend $T_g(1-\delta)$. Improving perceived quality of the health good in the public sector would increase the value that consumers attach to public providers. Thus, if public providers' quality is improved by β%, consumers will value quality at $q_g(1+\beta)$. Taking all these effects into account, the expected demand function, $D^{SR}$, and the respective market shares, $D_g^{SR}$ and $D_v^{SR}$, can be rewritten as follows:

$$D^{SR} = \sum_{i=1}^{2} [(\alpha N_{iu} + N_i)\{1 - (1 - \lambda \exp(-\lambda A_{2i}))((1 - \lambda \exp(-\lambda A_{3i}))\} \ ] \quad (18)$$

$$D_g^{SR} = \sum_{i=1}^{2} (\alpha N_{iu} + N_i)\{\exp(-\lambda A_{3i}) - \frac{1}{2}\exp(-\lambda(A_{2i} + A_{3i}))\} \quad (19)$$

$$D_v^{SR} = \sum_{i=1}^{2} (\alpha N_{iu} + N_i)\{\exp(-\lambda A_{2i}) - \frac{1}{2}\exp(-\lambda(A_{2i} + A_{3i}))\} \quad (20)$$

where

| | | |
|---|---|---|
| $N_{iu}$ | = | population in income group *i* that does not have knowledge of the health good |
| . | = | percentage of the population covered by the government intervention of increasing knowledge |
| $A_{2i}$ | = | $\log \{Y_{ki} / (Y_{ki} - [(1-.)P_v + T_v]\} - q_v$ |
| $A_{3i}$ | = | $\log \{Y_{ki} / (Y_{ki} - [P_g + (1-.)T_g\} - (1+.)q_g$ |
| . | = | percentage of private providers' fee that is subsidized |
| $P_j$ | = | fee charged by provider *j* |
| $T_j$ | = | travel and other costs incurred by consumers in procuring the good from provider *j* |
| . | = | percentage of consumers' out-of-pocket expenditure on travel and other costs that is subsidized |
| . | = | percentage improvement in perceived quality of the health good produced by public providers |

Next, we describe the budget of the government and note that each of the four interventions of the government has some direct and associated costs for the government. For ease of exposition, we assume that there are no fixed or lump sum costs of producing knowledge. Budget expenditure can be decomposed into "direct" and "associated" costs. The direct costs are those of increasing knowledge, which is simply the product of the unit cost per individual and the number of individuals "educated," and the costs of the subsidies, which are simply the product of unit subsidies and consumption of the health good from that source. The associated costs of increasing knowledge arise from costs of producing the good to meet the additional demand in the public sector and the cost of subsidizing the additional consumption from the private sector. Similarly, the other three interventions also have associated costs, since they affect the probability of consumption from either of the two providers. Since we know the respective shares of the public and the private providers, we can correctly allocate the associated costs of these interventions to the public providers.

In particular, we can write the incremental budget constraint of the government as follows:

$$dB = \sum_{i=1}^{2}\{\rho\alpha N_{iu} + \sigma P_v D_v^{SR} + (\kappa + \eta(1+\beta)q_g + t(1+\delta)T_g)D_g^{SR}\} \tag{21}$$

where

| | | |
|---|---|---|
| dB | = | incremental budget |
| . | = | cost of educating one individual |
| . | = | cost of production of one unit of the health good in the public sector |
| . | = | cost of increasing perceived quality of public production by one unit |
| . | = | cost of reducing consumer access costs by one unit |

Following standard maximization techniques, we set up the Lagrangian:

$$\begin{aligned} \textit{Maximize} \quad L = & \sum_{i=1}^{2}\left[(aN_{iu} + N_{\mathrm{i}})\{1-(1-l\exp(-lA_{2i}))((1-l\exp(-lA_{3i}))\}\right] \\ & + dB - (\sum_{i=1}^{2}\{\rho\alpha N_{iu} + \sigma P_v D_v^{SR} + (\kappa + \eta(1+\beta)q_g + \tau(1+\delta)T_g)D_g^{SR}\}) \end{aligned} \tag{22}$$

The choice variables are $\delta$, $\sigma$, $\alpha$ and $\beta$. All other variables are pre-determined.

## Solution

The first-order conditions of the above problem are:

$$\frac{\partial L}{\partial \alpha} = \sum_{i=1}^{2}\mathrm{N_{iu}}\{1-(1-\mathrm{w})(1-\mathrm{x})\} - \Lambda(\sum_{i=1}^{2}N_{iu}\{\rho + \sigma P_v D_v^{SR} + cD_g^{SR}\}) \tag{23}$$

$$\begin{aligned} \frac{\partial L}{\partial \beta} = & \sum_{i=1}^{2}\left[(N_i + \alpha N_{iu})\{(1-w)x\lambda q_g\}\right] \\ & - \Lambda(\sum_{i=1}^{2}(N_i + \alpha N_{iu})\{\frac{\lambda}{2}sP_v y(-q_g) + \eta q_g(x-\frac{1}{2}y) + c(x-y)\lambda q_g + c\frac{\lambda}{2}yq_g\} \end{aligned} \tag{24}$$

$$\frac{\partial L}{\partial d} = \sum (N_i + N_{iu})(1-w)x\frac{\lambda T_g}{Y_i - P_g - (1-d)T_g} \tag{25}$$
$$-\Lambda\sum (N_i + N_{iu})\{\frac{\lambda}{2}sP_v y(\frac{T_g}{Y_i - P_g - (1-d)T_g}) + tT_g(x-\frac{1}{2}y)$$
$$+c(x-y)\frac{\lambda T_g}{Y_i - P_g - (1-d)T_g} + cy\frac{\lambda}{2}\frac{T_g}{Y_i - P_g - (1-d)T_g}\}$$

$$\frac{\partial L}{\partial s} = \sum (N_i + \alpha N_{iu})(1-x)w\frac{\lambda P_v}{Y_i - P_v(1-s) - T_v} \tag{26}$$
$$-\Lambda\sum (N_i + \alpha N_{iu})\{P_v(w-\frac{1}{2}y) + \sigma P_v(w-y)\frac{\lambda P_v}{Y_i - P_v(1-\sigma) - T_v}$$
$$+\sigma P_v\frac{\lambda}{2}y\frac{P_v}{Y_i - P_v(1-\sigma) - T_v} + c(-\frac{\lambda}{2})y\frac{P_v}{Y_i - P_v(1-\sigma) - T_v}$$

$$\frac{\partial L}{\partial \Lambda} = dB - \sum_{i=1}^{2}\{\rho\alpha N_{iu} + sP_v D_v^{SR} + cD_g^{SR}\} \tag{27}$$

where

$$w = e^{-lA_{2k}} \tag{28}$$

$$x = e^{-lA_{3k}} \tag{29}$$

$$y = e^{-l(A_{2k}+A_{3k})} \tag{30}$$

Equating the first-order conditions to zero and solving yields the values for the endogenous variables that maximizes the objective function subject to the budget constraint. We give a flavor of the decision rule in the equation 31, where for expositional clarity, $\delta$ and $\beta$ have been set to zero.

$$\frac{\frac{\partial P(C)}{\partial \sigma}}{P_v\left(P(v)+\sigma\frac{\partial P(v)}{\partial \sigma}\right)+\kappa\frac{\partial P(g)}{\partial \sigma}} = \frac{P(C)}{r+\sigma P_v P(v)+\kappa P(g)} \tag{31}$$

The left-hand side of equation 31 is the ratio between the marginal increase in the health coverage due to a marginal increase in the private sector subsidy. Similarly, the right-hand side of equation 31 is the ratio between the marginal increase in health coverage due to increasing knowledge in the population and the marginal cost associated with increasing knowledge. In other words, the decision-rule suggested by the first order condition is that governments must allocate their incremental budget so as to equalize, for every intervention, the ratio of marginal increase in demand resulting from a particular intervention to the costs associated with that intervention.

## Comparative Statics

Our model can be used to predict how the equilibrium values of the endogenous variables, which are the four interventions, will change when there is a change in any of the exogenous variables or parameters, chiefly the budget and costs of the interventions. For purposes of demonstration, we consider the effect of a change in the incremental budget on the amount of private-sector subsidy and on the number of people educated. We also consider the effects of a change subsidy costs on the amount of subsidy as well as on the number of people educated.

$$\frac{\partial \sigma}{\partial (dB)} = \frac{1}{|J|}\left\{N_{iu}{}^2\frac{\partial P(C)}{\partial \sigma}\left(\rho+\sigma P_v P(v)+\kappa P(g)\right)\right\} \tag{32}$$

where P(v) is the probability that an individual will purchase the good from the private provider and P(g) is the probability that the individual will purchase the health good from the public provider. The Jacobian, |J|, has the same value as the bordered Hessian, and is positive if the second-order conditions for a maximum are met. Equation 32 is positive so long as an increase in subsidy for private production increases the probability of consumption, implying that an increase in the government budget would lead to an increase in subsidy for private production, everything else remaining constant. This is an expected result.

$$\frac{\partial \alpha}{\partial (dB)} = -\frac{1}{|J|}\left\{\begin{array}{l}\left(N_{iu}(\rho+\sigma P_v P(v)+\kappa P(g))(N_i+\alpha N_{iu})\frac{\partial^2 P(C)}{d\sigma^2}\right)- \\ \left((N_i+N_{iu})(P_v P(v)+\sigma P_v\frac{\partial P(v)}{\partial \sigma}+k\frac{\partial P(v)}{\partial \sigma})(N_{iu}\frac{\partial P(C)}{\partial \sigma}\right)\end{array}\right\} \tag{33}$$

Similarly, equation 33 is also positive, implying that an increase in the government budget would lead to greater outlays on improving awareness and knowledge among potential consumers. This is also an expected result.

$$\frac{\partial \sigma}{\partial P_v} = -\frac{\sigma}{|J|}\left\{ {N_{iu}}^2 \frac{\partial P(C)}{\partial \sigma}\left(r + \sigma P_v P(v) + \kappa P(g)\right)\right\} + \frac{\Lambda}{|J|}\left\{N_{iu}\left(r + \sigma P_v P(v) + \kappa P(g)\right)\right\}^2 \tag{34}$$

We decompose the effect of a change in the cost of an intervention into two parts: the first term in equation 34 is the effective reduction in the available budget (also called the income effect); the second term in equation 34 is the effective decrease in the costs of other interventions (also known as the substitution effect). The substitution effect is unambiguously negative. The income effect will also be negative so long as an increase in the use of one intervention does not lead to fall in the gain in health coverage due to other interventions already in use. Since this is not likely to be the case, the income effect will reinforce the negative substitution effect, and the combined effect will also be negative.

$$\begin{aligned}\frac{\partial \sigma}{\partial P_v} = \frac{\sigma}{|J|}\left\{\left( N_{iu}(\rho + \sigma P_v P(v) + \kappa P(g))(N_i + \alpha N_{iu})\frac{\partial^2 P(C)}{d\sigma^2}\right) - \right. \\ \left.\left((N_i + N_{iu})(P_v P(v) + \sigma P_v \frac{\partial P(v)}{\partial \sigma} + k\frac{\partial P(v)}{\partial \sigma})(N_{iu}\frac{\partial P(C)}{\partial \sigma}\right)\right\} \\ -\frac{\Lambda}{|J|}\left\{N_{iu}(\rho + \sigma P_v P(v) + \kappa P(g))\right\}\left\{(N_i + N_{iu})(P_v P(v) + \sigma P_v \frac{\partial P(v)}{\partial \sigma} + k\frac{\partial P(v)}{\partial \sigma})\right\}\end{aligned} \tag{35}$$

Finally, we examine the impact of a change in the costs of one intervention on the optimal purchase of the other intervention. We again decompose the comparative-static derivative into two components, an income effect and a substitution effect. The first term in equation 35 is the income effect and is negative. The second term is the substitution effect, and is positive. The combined effect will depend on the relative strengths of the two and is indeterminate.

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